Electronic Notes in Theoretical Computer Science 53 (2002)
URL: http://www.elsevier.nl/locate/entcs/volume53.html 13 pages

# Polish Negation and Lexical Resource Semantics [1]

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**Abstract**

Using negative concord phenomena in Polish, we introduce and motivate Lexical Resource Semantics (LRS), a new framework for combinatorial semantics with type-theoretic representation languages in HPSG. LRS combines techniques first investigated within theories of semantic underspecification with HPSG-specific formal devices to derive fully specified logical representations of linguistic expressions.

## 1 Introduction

In this paper we present a new framework of combinatorial semantics for HPSG, *Lexical Resource Semantics* (LRS). LRS combines techniques and advantages of so-called "underspecified" semantic systems such as UDRT [12], MRS [5, 6, 7], UMRS [10, 11] or FUDRT [9] with the conceptual clarity of non-underspecified semantic representations. The goal is to take advantage of the formal power and flexibility of HPSG-specific techniques of linguistic description while using standard, type-theoretic semantic representations that are independent of the HPSG framework and easily accessible to a broader audience. We will use data from Polish negation to illustrate LRS. Negation is a scope-bearing element which interacts with quantification, and this property makes a treatment in terms of underspecification very attractive. In addition, much work within HPSG has been devoted to both the empirical and the theoretical sides of Polish

[1] We would like to thank Adam Przepiórkowski for discussion, Beata Trawiński for help with Polish and Janina Radó for help with English and with the structure of our paper.
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negation [16, 19, 20, 21, 22, 24]. The insights presented in these papers form the empirical background to our discussion.

We will focus on the semantics of the Polish negative marker *nie* (glossed as NM) which precedes the tensed verb in negated clauses, and of so-called *n-words* such as *nikt* (*nobody*) and *żaden N* (*no N*).

(1) Jan **nie** pomaga ojcu.
Jan NM helps father
'Jan doesn't help his father.'

As we will see, *nie* and n-words are both inherently negative. This leads to a seemingly contradictory situation in sentences such as (2), which only have a *negative concord* [NC] reading, but no *double negation* [DN] reading.

(2) Jan nie pomaga nikomu.
Jan NM helps nobody
'Jan doesn't help anybody.' [NC]
**not**: 'Jan doesn't help nobody.' [DN]

In LRS the apparent paradox can be resolved elegantly by assuming *token identity* of the two negations in the semantic representation language.

## 2 Polish Negation

Polish n-words occur, without any additional marking of negativity, in a number of negative contexts, such as short answers (3), coordinations (4), and some comparatives (5).

(3) Kogo widziałeś? Nikogo.
Who have you seen? Nobody.GEN/ACC.

(4) Chcę poślubić albo Piotra, albo nikogo.
I want to marry either Piotr or nobody

(5) Kocham ją jak [żadną inną].
I love her.ACC as [no other].ACC
'I love her more than (I love) any other (girl).'

In all of these examples, the n-word is the only possible element that contributes negation to the meaning. We conclude that there is evidence for an inherent negativity in the meaning of Polish n-words.

The contexts of the n-words in (3)–(5) are non-clausal. If an n-word occurs in a clause, the verb must be preceded by the preverbal negative marker *nie* for the sentence to be grammatical. As already noted above (2), such sentences only have a negative concord reading but no double negation reading.

(6) Janek *(nie) pomaga nikomu.
Janek NM helps nobody
'Janek doesn't help anybody.' [NC]
**not:** 'Janek doesn't help nobody.' [DN]

The NC phenomenon in Polish is not restricted to contexts with preverbal *nie* and a single n-word; there may be several n-words within a clause. Still, the presence of *nie* remains obligatory and a single negation reading is the only possible interpretation.

(7) Nikt *(nie) pomaga nikomu.
Nobody NM helps nobody
'Nobody helps anybody.'

Although n-words seem not to contribute negation independently to the meaning of negated clauses, they cannot be regarded as *Negative Polarity Items* such as English *any* [14, 17], because they are not felicitous in typical NPI licensing environments other than under overt negation. This is shown with an interrogative context in (8).

(8) * Widziałeś nikogo?
you-saw nobody
(putative meaning: 'Did you see anybody?')

From these data we conclude that Polish n-words are inherently negative. However, to account for their concord behavior, additional licensing principles of Polish must be used to block the semantic negativity from appearing independently in clauses.

In the next section, we present the semantic framework of LRS, which will allow us to develop an analysis of the concord behavior of Polish n-words that respects their inherently negative meaning. We will reduce negative concord to simple token identity of the negations contributed by negative elements in a single clause (*nie* and n-words).

## 3 Lexical Resource Semantics

The crucial innovation of LRS is a special technique for combinatorial semantics, tailored to the formal language and model theory of HPSG, which is applied to terms of some independently chosen semantic representation language. For purposes of exposition, we adopt the familiar language of first order logic as semantic representation language. To integrate it with an HPSG grammar, we adopt the proposal in [25] and extend the HPSG signature with an appropriate sort hierarchy under a new sort *term*, where entities of sort *term* correspond to terms of our semantic representation language, and we add appropriate principles to the grammar that restrict the configurations of entities under *term* entities in the desired way. Given these extensions, there are entities in the models of our grammar which correspond to the term in (9a). They have components of sort *term* which correspond to the terms in (9b).

(9) a. $\exists x[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$

b. $\exists x[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$, $x$, $[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$, $\mathsf{human}'(x)$, $\mathsf{human}'$, $\mathsf{come}'(x)$, $\mathsf{come}'$

Furthermore, we introduce a sort *lrs* and assume that the CONTENT value of a *sign* is an entity of sort *lrs*. Three attributes are appropriate for the sort *lrs*:

(10) The feature declarations of the sort *lrs*:

| | | |
|---|---|---|
| *lrs* | TOP | *term* |
| | MAIN | *term* |
| | PARTS | *list(term)* |

In words, the CONTENT MAIN value is the semantic term that is associated with the word's basic meaning. In an utterance, the TOP value is the term that corresponds to the logical form of the overall utterance. The PARTS list of a sign contains exactly those subterms of the logical form of utterances that belong to the semantic contribution of the sign.

For illustration, consider the following simple Polish sentence, whose logical form is the term given in (9a).

(11) Ktoś przyśedł.
someone came

(12) shows the relevant parts of the lexical entry of *ktoś* (*someone*). Its CONTENT value is an lrs whose MAIN value expresses the restriction to humans. The TOP value of the NP is an existential quantifier. The relation $\triangleleft$, "*component of*", indicates that the term $\boxed{1}$ is a *component* (a subterm) of the term $\alpha$. This additional condition guarantees that the term $\mathsf{human}'(x)$ appears in the restriction of the quantifier. The PARTS list contains exactly those terms that are contributed by the word *ktoś*.

(12) Parts of the lexical entry of *ktoś* (*someone*):

$$\begin{bmatrix} \textit{word} \\ \text{PHON } \langle \textit{ktoś} \rangle \\ \text{SYNS LOC} \begin{bmatrix} \text{CAT HEAD } \textit{noun} \\ \text{CONT} \begin{bmatrix} \textit{lrs} \\ \text{TOP} & \boxed{2}\, \exists x[\alpha \wedge \beta] \\ \text{MAIN} & \boxed{1}\, \mathsf{human}'(x) \\ \text{PARTS} & \langle x, \boxed{1}, \boxed{1a}\, \mathsf{human}', \boxed{2}, \boxed{2a}\, \alpha \wedge \beta \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \;\&\; \boxed{1} \triangleleft \alpha$$

Analogously, the lexical entry for the verb *przyszedł*:

(13) Parts of the lexical entry of *przyszedł* (*came*):

$$\left[\begin{array}{ll}\textit{word} & \\ \text{PHON} & \langle \textit{przyszedł} \rangle \\ \text{SYNS LOC} & \left[\begin{array}{ll}\text{CAT HEAD } \textit{verb} & \\ \text{CONT} & \left[\begin{array}{ll}\textit{lrs} & \\ \text{TOP} & \textit{term} \\ \text{MAIN} & \boxed{3}\,\mathsf{come}'(x) \\ \text{PARTS} & \left\langle x, \boxed{3}, \boxed{3a}\,\mathsf{come}' \right\rangle \end{array}\right]\end{array}\right]\end{array}\right]$$

Every lrs obeys the MAIN PRINCIPLE (MP) and the TOP PRINCIPLE (TP). The MP states that the term in the MAIN value of every lrs is a subterm of the TOP value and a member of the PARTS list. The crucial part of the TP for the analysis we present below is that in an utterance, the TOP value of the utterance consists of exactly those terms that occur in its PARTS list. Technically, utterances are phrases with illocutionary force and are not embedded within any other phrase.

In order to derive the logical form of sentence (11) we need a principle that determines the CONTENT value of a phrase on the basis of the CONTENT values of its daughters. We call this principle the SEMANTICS PRINCIPLE (SP). According to the SP the TOP value of a phrase and of its head daughter are identical, and the MAIN value is also shared along the head projection. The PARTS list of a phrase is the concatenation of the PARTS lists of its daughters. In addition, depending on the elements that are combined, the SP introduces subterm requirements. In our example, a quantified NP and a verb are combined. In this situation, the SP states that the MAIN value of the head daughter must be in the nuclear scope of the quantified NP. In (14) we show the analysis of sentence (11).

(14) The analysis of sentence (11):

$$\left[\begin{array}{ll}\text{TOP} & \boxed{2} \\ \text{MAIN} & \boxed{3} \\ \text{PARTS} & \left\langle x, \boxed{1}, \boxed{1a}, \boxed{2}, \boxed{2a}, \boxed{3}, \boxed{3a} \right\rangle \end{array}\right] \;\&\; \boxed{3} \triangleleft \beta$$

COMP HEAD

*Ktoś* *przyszedł*

Due to the SP, the MAIN value of the phrase is identical to that of the verb and the overall PARTS list contains exactly the elements of the PARTS lists of the words *ktoś* and *przyszedł*, as introduced in the lexical entries in (12) and (13). In addition, the SP introduces the condition that the MAIN value of the head daughter (the term $\mathsf{come}'(x)$, referred to with the tag $\boxed{3}$) be a subterm of the nuclear scope of the quantifier in subject position (i.e., the term referred to as $\beta$).

There is only one term in the PARTS list of the sentence that consists of all other terms in the list and respects the subterm requirements introduced by the lexical entries and the SP: the TOP value of the subject NP, $\boxed{2}$.

Thus, it follows by the TP that $\boxed{2}$ is the TOP value of the sentence.

In sum, in LRS combinatorial semantics results by concatenation of the semantic contributions of the words that make up a sentence. The task of the SP is to impose certain subterm/scope relations among their semantic contributions. For cases of scope ambiguity, however, the SP does not impose subterm requirements. As a consequence, scope ambiguities are handled without particular mechanisms such as a Cooper storage as in [18]. Still, the TOP value of a sentence is always a term of the underlying semantic representation language and, as such, expresses a fully scoped reading of the sentence.

## 4 The Analysis

In this section, we sketch the LRS analysis of the simple negative sentence in (15):

(15) Nikt nie przyszedł.
nobody NM came.
'Nobody came.'

Following [15, 16] we assume that preverbal *nie* is a verbal prefix, and a *nie*-V complex is analyzed as a word. Without going into details of how such a complex is formed, we describe the word *nie przyszedł* in (16). In addition to the terms on the PARTS list of the non-negated verb in (13), the NM-prefixed verb also contains a negation (the term $\neg\delta$) and the requirement that its MAIN value $\boxed{3}$ be a subterm of $\delta$, i.e., that it be in the scope of the negation.

(16) Description of the word *nie przyszedł*:

$$\begin{bmatrix} \textit{word} & \\ \text{PHON } \langle \textit{nie przyszedł} \rangle & \\ \text{SYNS LOC CONT} & \begin{bmatrix} \textit{lrs} & \\ \text{TOP} & \textit{term} \\ \text{MAIN} & \boxed{3}\,\text{come}'(x) \\ \text{PARTS} & \langle x, \boxed{3}, \boxed{3a}\text{come}', \boxed{5}\neg\delta, \rangle \end{bmatrix} \end{bmatrix} \& \ \boxed{3} \triangleleft \delta$$

In (17) we give the (relevant parts of) the lexical entry of the n-word *nikt* (*nobody*). It is very similar to that of *ktoś* in (12),[4] but it contains a negation in its PARTS list (the term $\neg\gamma$, referred to with $\boxed{4}$). In the lexical entry of the n-word we specify that the MAIN value be part of the restriction of the existential quantifier and that the TOP value of the n-word be in the scope of the negation which it introduces.

[4] Some analyses of Polish negation assume that n-words are indefinites rather than quantifiers [1, 24]. As this issue is orthogonal to the question of their inherent negativity, we will ignore it here.

(17) Parts of the lexical entry of *nikt* (*nobody*):

$$\left[\begin{array}{ll} \textit{word} & \\ \text{PHON } \langle \textit{nikt} \rangle & \\ \text{SYNS LOC CONT} & \left[\begin{array}{ll} \textit{lrs} & \\ \text{TOP} & \boxed{2}\,\exists x[\alpha \wedge \beta] \\ \text{MAIN} & \boxed{1}\,\mathsf{human}'(x) \\ \text{PARTS} & \langle x, \boxed{1}, \boxed{1a}\mathsf{human}', \boxed{2}, \boxed{2a}[\alpha \wedge \beta], \boxed{4}\neg\gamma \rangle \end{array}\right] \end{array}\right] \;\&\; \boxed{1} \triangleleft \alpha \;\&\; \boxed{2} \triangleleft \gamma$$

In (18) we give the analysis of the simple negated sentence in (15). Just like in the tree described in (14), the SP imposes the condition that the MAIN value of the head ($\boxed{3}$) be in the nuclear scope of the quantifier contributed by the subject.

(18) Analysis of a simple NC sentence:

S

$$\left[\begin{array}{ll} \text{TOP} & \boxed{6} \\ \text{MAIN} & \boxed{3} \\ \text{PARTS} & \langle x, \boxed{1}, \boxed{1a}, \boxed{2}, \boxed{2a}, \boxed{3}, \boxed{3a}, \boxed{4}, \boxed{5} \rangle \end{array}\right] \;\&\; \boxed{3} \triangleleft \beta$$

COMP HEAD

*Nikt* *nie przyszedł*

Our principles license three possible values for the TOP attribute of the sentence, these are listed in (19). The first two readings differ in whether the negation contributed by the negated verb has scope over that contributed by the subject (19a) or the other way around (19b). Finally, (19c) expresses the situation where the two negations are identical, i.e., where the terms $\boxed{4}$ and $\boxed{5}$ are identical. In fact, this is the only possible reading of (15).

(19) a. $\boxed{4} \triangleleft \boxed{5}$ and $\boxed{5} = \boxed{6}$: $\neg\neg\exists x[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$

b. $\boxed{5} \triangleleft \boxed{4}$ and $\boxed{4} = \boxed{6}$: $\neg\exists x\neg[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$

c. $\boxed{4} = \boxed{5} = \boxed{6}$: $\neg\exists x[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]$

To exclude the (19a) and the (19b) readings, we impose the following language-specific constraint for Polish:

(20) The NEGATION COMPLEXITY CONSTRAINT (NCC)
For each sign, there may be at most one negation that is a component of the TOP value and has the MAIN value as its component.

(19a) and (19b) violate the NCC because there are two negations in the TOP value ($\boxed{6}$), both having scope over the MAIN value of the sentence.

The NCC is language-specific. Since Polish is an obligatory NC language, there may be at most one sentential negation. For French, an optional NC language, [8] argues that there might be maximally two negations. The NCC achieves the same effect as the *negation absorption* operation of [13], but, whereas negation absorption comes as a completely new and stipulated mechanism, the NCC enforces structural identities, just as most HPSG principles do (such as the identity of HEAD values in the HEAD FEATURE PRINCIPLE).

The NCC immediately accounts for further data. It predicts that in non-clausal contexts such as those illustrated in (3)–(5), we get at most one negation, even if there are several n-words:

(21) Poślubię albo tę dziewczynę z Poznania, albo żadnej
I will marry either [this girl].ACC from Poznan or [no
dziewczyny z żadnego miasta.
girl].GEN from no city.
'I will either marry this girl from Poznan or no girl from any city.'

Instances of "double negation" are only permitted if the negations are not part of the same head projection. In (22) the higher verb *może* is in the scope of a single negation and so is the lower verb *znać* within its own projection.

(22) Tomek nie może nie znać Marii.
Tomek NM may NM know Maria
'It is not the case that it is possible that Tomek does not know Maria.'

The NCC enforces the NC reading of Polish n-words. A second language-specific principle must guarantee the presence of *nie* in negated clauses. Following [13] we call it the NEG CRITERION.

(23) The NEG CRITERION (NegC):
For every verb, if there is a negation in the TOP value of the verb that has scope over the MAIN value of the verb, then that negation must be an element of the PARTS list of the verb.

For illustration of the NegC, consider the tree in (24). The only element of the overall PARTS list that can satisfy the TP is the term $\boxed{4}$ which contains the negation and is contributed by the n-word. According to the SP, the TOP value of the head is identical to that of the phrase. Thus, the verb *przyszedł* has a TOP value which contains a negation, and the negation in turn has scope over its MAIN value. The NegC requires, then, that the negation be also part of the verb's PARTS list, which is not the case. The structure in (24) is, thus, excluded by the NegC.

(24) A violation of the NegC:

$$\text{S}\;\begin{bmatrix}\text{TOP} & \boxed{4}\,\neg\exists x[\mathsf{human}'(x) \wedge \mathsf{come}'(x)]\\ \text{MAIN} & \boxed{3}\,\mathsf{come}'(x)\\ \text{PARTS} & \langle x, \boxed{1}, \boxed{1a}, \boxed{2}, \boxed{2a}, \boxed{3}, \boxed{3a}, \boxed{4}\rangle\end{bmatrix}$$

COMP — HEAD

$$\underset{\textit{* Nikt}}{\text{NP}\;\begin{bmatrix}\text{TOP} & \boxed{2}\\ \text{MAIN} & \boxed{1}\\ \text{PARTS} & \langle x, \boxed{1}, \boxed{1a}, \boxed{2}, \boxed{2a}, \boxed{4}\rangle\end{bmatrix}} \qquad \underset{\textit{przyszedł}}{\text{V}\;\begin{bmatrix}\text{TOP} & \boxed{4}\\ \text{MAIN} & \boxed{3}\\ \text{PARTS} & \langle x, \boxed{3}, \boxed{3a}\rangle\end{bmatrix}}$$

Our analysis of NC in Polish shows how token identity can be used in combinatorial semantics to arrive at a natural account of concord phenomena. While the analysis is similar in spirit to GB analyses in the tradition of [13], we do not need any stipulated mechanisms such as *negation factorization*. Instead, we can simply use the major analytical tool of HPSG, token identity.

For reasons of space, here we have restricted our attention to the case of finite verbs and their complements. For a broader coverage of data, we would have to consider syntactic islands for negative concord as well as a more careful semantic distinction among different kinds of negation such as eventuality, metalinguistic and pleonastic negation, only the first of which licenses n-words in Polish, cf. [22]. Our account naturally generalizes to this more comprehensive set of data once we introduce the necessary syntactic and semantic refinements.

## 5 LRS and MRS

LRS is similar to underspecified semantic systems in using a list-like semantic representation. Thus, we can avoid Cooper storage mechanisms for capturing different scoping possibilities of quantifiers [3, 4]. Combinatorial semantics results by simply concatenating lists of subterms instead of introducing complicated syntactic mechanisms such as $\lambda$-conversion, as would be needed in Montagovian systems. In this respect, LRS shares many advantages of underspecified systems. At the same time, the semantic representations used in LRS are not underspecified. This hybrid status helps to avoid empirical and theoretical problems that underspecified systems usually face. The technical and conceptual differences between LRS and underspecified semantic systems will be demonstrated through an explicit comparison with Minimal Recursion Semantics, MRS [5, 6, 7], which was originally developed for computer implementations.

### 5.1 *Empirical problems of underspecified systems*

In some cases, a sentence becomes ungrammatical because the scoping requirements of the elements involved cannot be successfully resolved. A representative example is given for Polish negation in [22, p. 216]. The authors show that the preverbal particle *nie* is systematically ambiguous between eventuality negation (as in all our examples above) and non-eventuality negation (pleonastic or other). Sentences introduced by *omal* (*almost*) such as (25) constitute contexts for the non-eventuality use of *nie*. As the dual function of *nie* is systematic, it is plausible to leave the particular use of *nie* underspecified in a semantic representation.

(25) Omal jej nie przewróciłem.
almost her NM I overturned
'I almost knocked her over.'

In Section 2 we showed that n-words must co-occur with *nie* in clauses. In such a constellation, however, *nie* can only have its regular use as eventuality negation. This leads to a conflict in (26).

(26) ?* Omal nikogo nie przewróciłem.
almost nobody NM I overturned

In (26), the n-word requires an eventuality negation interpretation of *nie*, but *omal*, just as in (25), requires a non-eventuality negation. If, as suggested above, the interpretation of *nie* is not specified in the semantic representation of (26), the conflicting requirements of *omal* and *nikogo* cannot be expressed in the grammar itself.

### 5.2 *Technical differences between LRS and MRS*

The major similarity between LRS and MRS is the use of list structures as semantic representations. But, whereas the lists contain subterms of the overall logical form of a sign in LRS, MRS superimposes on them an extra *handle* structure to put the pieces together. The handle structure leads to a special treatment of conjunction and is mainly motivated by computational considerations from machine translation. The additional layer of structure makes it hard to express certain well-formedness conditions on semantic representations as part of the grammar. Examples are the condition that there be no free variables in the logical form of a sentence, or that there be a way to order the handles to form a non-cyclic tree-like structure which guarantees the existence of a fully scoped mrs. MRS, and UMRS [10, p. 46], explicitly say that these constraints are not part of the HPSG grammar; they belong to some extra-grammatical scope-resolution procedure.

LRS does not work with underspecified representations. Thus, if there is a semantic representation for a sentence, that guarantees the existence of a fully scope-resolved reading. Similarly, as standard definitions of free variable occurrences only rely on the existence of a subterm relation, it is straightforward to express constraints like the VARIABLE BINDING CONDITION as part of the grammar in LRS.

Another consequence of the handle mechanism and of the fact that semantic representations are not fully scoped is that the kind of constraints on scopings is very limited in MRS. There is, at present, no discussion of what type of constraints is needed, and underspecified systems differ with respect to the type they use: [2] only allows *"is a subterm of"*; in [10] there are constraints of the form *"is possibly in the immediate scope of"* and *"cannot possibly be in the immediate scope of"*. The various drafts of the work in progress describing MRS differ with respect to the kinds of constraints. In [12] there are even more complex constraints of the form *"if $l_1$ is in the scope of $l_2$, then $l_3$ is in the scope of $l_4$"*. In a non-underspecified system such as LRS, subordination constraints need not be expressed in terms of particular linguistic structures designed for that purpose. They are implicit in the structure of the terms themselves. Therefore, it is possible to express even complex scopal constraints as principles of grammar without enriching the algebraic structure of the models of the grammar.

## 6 Conclusion

We have shown how a core set of data of Polish negative concord can be captured in LRS, a new semantic framework for HPSG. LRS enables us to analyze Polish n-words as inherently negative by reducing negative concord to token identity of the negations that are introduced by multiple exponents of negation in a clause.

LRS provides a technique to integrate standard logical languages with methods of implementing combinatorial semantics as list concatenation instead of more complex operations such as functional application. It eschews the use of a designer representation language with a complicated and possibly formally vague extra-grammatical translation into a logical language that can be interpreted model-theoretically. No special devices are needed in order to capture scope ambiguities. Underspecification in LRS is underspecification at the level of HPSG's description language, which is where it originally belongs in constraint-based varieties of HPSG [23]; it is not underspecification on the level of the semantic representation language. Moreover, since any standard representation language can be substituted for the one we have used in this paper, LRS is expressively well-suited for the description of complex semantic phenomena. Finally, as we have seen in the application to Polish, it can also easily and modularly be combined with the usual syntactic analyses of HPSG. Further research will have to investigate if LRS can also serve as a feasible framework for computing with HPSG grammars.

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